

## PENDING CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application.

1. (Previously Presented) A method of estimating a communication channel impulse response  $h(t)$ , comprising the steps of:

generating  $co_m(t) = co(t + mNT_c)$  for  $m = 0, 1, \dots, M$  by correlating a received signal  $r(t)$  with a spreading sequence  $S_i$  of length  $N$ , wherein the received signal  $r(t)$  comprises a chip sequence  $c_j$  applied to a communication channel characterizable by the communication channel impulse response  $h(t)$ , and wherein the chip sequence  $c_j$  is generated from a data sequence  $d_i$  spread by the spreading sequence  $S_i$ , and wherein  $T_c$  is the chip period of the chip sequence  $c_j$ ;

generating an estimated communication channel impulse response  $\hat{h}_M(t)$  as a combination of  $co_m(t)$  and  $d_m$  for  $m = 0, 1, \dots, M$ , where  $d_m$  is the  $m$ -th symbol and  $M$  is number of symbols used to generate the estimated communication channel impulse response  $\hat{h}_M(t)$ ; and

filtering the estimated communication channel impulse response  $\hat{h}_M(t)$  with a filter  $f$  to generate a filtered estimate of the communication channel impulse response  $h(t)$ , the filter  $f$  being selected at least in part according to the spreading sequence  $S_i$ .

2. (Original) The method of claim 1, wherein the filter  $f$  is further selected at least in part according to an autocorrelation  $A(n)$  of the spreading sequence  $S_i$ .

3. (Previously Presented) The method of claim 2, wherein the filter  $f$  is further selected at least in part according to the duration of the communication channel impulse response  $h(t)$ .

4. (Previously Presented) The method of claim 2, wherein the filter  $f$  is further selected at least in part according to a zero-forcing criteria

$$\sum_{i=-L}^L (A(n-i) \bullet f(i)) = A_f(n), \quad -L \leq n \leq L, \text{ wherein:}$$

$f(i)$  is an impulse response of the filter  $f$  such that  $A_f(n)$  is a convolution of  $A(n)$  and  $f(i)$ ;

$$A_f(n) = 1 \text{ for } n = 0 \text{ and } A_f(n) = 0 \text{ for } 0 < |n| \leq L; \text{ and}$$

$$A(n) = A(-n) = \sum_{i=0}^{N-1-n} S_i \bullet S_{i+n}, \quad 0 \leq n \leq N.$$

5. (Original) The method of claim 4, wherein:  
the parameter  $L$  is chosen such that a time duration of the impulse response of the communication channel  $h(t)$  is less than  $LT_c$ .

6. (Original) The method of claim 4, wherein:  
the parameter  $L$  is chosen such that a time duration of the impulse response of the communication channel  $h(t)$  is approximately equal to  $LT_c$ .
7. (Original) The method of claim 1, wherein  $N$  is less than 20.
8. (Previously Presented) The method of claim 1, wherein  $M = 1$ .
9. (Previously Presented) The method of claim 1, wherein the data sequence  $d_i$  includes a constrained portion  $Cd_i$  associated with at least two codes  $w_0, w_1$ , wherein a correlation  $A_{code}(k)$  of the constrained portion  $Cd_i$  with one of the codes  $w_0, w_1$  is characterized by a maximum value at  $k = 0$  and less than maximum values at  $k \neq 0$ .
10. (Previously Presented) The method of claim 1, wherein the step of generating an estimated communication channel impulse response  $\hat{h}_M(t)$  as a combination of  $co_m(t)$  and  $d_m$  for  $m = 0, 1, \dots, M$  comprises the step of computing  $\hat{h}_M(t)$  as
 
$$(1/M) \sum_{m=0}^{M-1} d_m \bullet co(t + mNT_c).$$
11. (Original) The method of claim 10, wherein  $M = 2$ .

12. (Original) The method of claim 9, wherein the data sequence  $d_i$  includes a preamble having a pseudorandom code including the constrained portion of the data sequence  $d_i$ .

13. (Original) The method of claim 9, wherein  $A_{code}(k) = 1$  at  $k = 0$  and  $A_{code}(k) = 0$  for substantially all  $k \neq 0$ .

14. (Original) The method of claim 9, wherein  $A_{code}(k) = 0$  for  $0 < |k| \leq J$ , wherein  $J$  is selected to minimize the correlation of the constrained portion  $Cd_i$  with the one of the codes  $w_0, w_1$  for substantially all  $k \neq 0$ .

15. (Original) The method of claim 14, wherein  $2J$  is a length of the constrained portion  $Cd_i$ .

16. (Previously Presented) The method of claim 9, wherein  $A_{code}(k) = 1$  at  $k = 0$  and  $A_{code}(k) \approx 0$  for substantially all  $k \neq 0$ .

17. (Previously Presented) The method of claim 9, wherein each of the at least two codes  $w_0, w_1$  comprises two symbols.

18. (Previously Presented) The method of claim 9, wherein each of the at least two codes  $w_0, w_1$  comprises no more than two symbols.

19. (Previously Presented) The method of claim 9, wherein the codes  $w_0, w_1$  comprise Walsh codes.

20. (Previously Presented) An apparatus for estimating a communication channel impulse response  $h(t)$ , comprising:

means for generating  $co_m(t) = co(t + mNT_c)$  for  $m = 0, 1, \dots, M$  by correlating a received signal  $r(t)$  with a spreading sequence  $S_i$  of length  $N$ , wherein the received signal  $r(t)$  comprises a chip sequence  $c_j$  applied to a communication channel characterizable by the communication channel impulse response  $h(t)$ , and wherein the chip sequence  $c_j$  is generated from a data sequence  $d_i$  spread by the spreading sequence  $S_i$ , and wherein  $T_c$  is the chip period of the chip sequence  $c_j$ ;

means for generating an estimated communication channel impulse response  $\hat{h}_M(t)$  as a combination of  $co_m(t)$  and  $d_m$  for  $m = 0, 1, \dots, M$ , where  $d_m$  is the  $m$ -th symbol and  $M$  is number of symbols used to generate the estimated communication channel impulse response  $\hat{h}_M(t)$ ; and

means for filtering the estimated communication channel impulse response  $\hat{h}_M(t)$  to generate a filtered estimate of the communication channel impulse response  $h(t)$ , the means for filtering selected at least in part according to the spreading sequence  $S_i$ .

21. (Previously Presented) The apparatus of claim 20, wherein the means for filtering is further selected at least in part according to an autocorrelation  $A(n)$  of the spreading sequence  $S_i$ .

22. (Previously Presented) The apparatus of claim 21, wherein the means for filtering is further selected at least in part according to the duration of the communication channel impulse response  $h(t)$ .

23. (Previously Presented) The apparatus of claim 21, wherein means for filtering is further selected at least in part according to a zero-forcing criteria

$$\sum_{i=-L}^L (A(n-i) \bullet f(i)) = A_f(n), \quad -L \leq n \leq L, \text{ wherein:}$$

$f(i)$  is an impulse response of the filter means  $f$  such that  $A_f(n)$  is a convolution of  $A(n)$  and  $f(i)$ ;

$$A_f(n) = 1 \text{ for } n = 0 \text{ and } A_f(n) = 0 \text{ for } 0 < |n| \leq L; \text{ and}$$

$$A(n) = A(-n) = \sum_{i=0}^{N-1-n} S_i \bullet S_{i+n}, \quad 0 \leq n \leq N.$$

24. (Original) The apparatus of claim 23, wherein:  
the parameter  $L$  is chosen such that a time duration of the impulse response of the communication channel  $h(t)$  is less than  $LT_c$ .

25. (Original) The apparatus of claim 23, wherein:  
the parameter  $L$  is chosen such that a time duration of the impulse response of the communication channel  $h(t)$  is approximately equal to  $LT_c$ .

26. (Original) The apparatus of claim 20, wherein  $N$  is less than 20.

27. (Previously Presented) The apparatus of claim 20, wherein  $M = 1$ .

28. (Previously Presented) The apparatus of claim 20, wherein the data sequence  $d_i$  includes a constrained portion  $Cd_i$  associated with at least two codes  $w_0, w_1$ , wherein a correlation  $A_{code}(k)$  of the constrained portion  $Cd_i$  with one of the codes  $w_0, w_1$  is characterized by a maximum value at  $k = 0$  and less than maximum values at  $k \neq 0$ .

29. (Previously Presented) The apparatus of claim 20, wherein the means for generating an estimated communication channel impulse response  $\hat{h}_M(t)$  as a combination of  $co_m(t)$  and  $d_m$  for  $m = 0, 1, \dots, M$  comprises means for computing  $\hat{h}_M(t)$  as

$$(1/M) \sum_{m=0}^{M-1} d_m \bullet co(t + mNT_c).$$

30. (Original) The apparatus of claim 29, wherein  $M = 2$ .

31. (Original) The apparatus of claim 28, wherein the data sequence  $d_i$  includes a preamble having a pseudorandom code including the constrained portion of the data sequence  $d_i$ .

32. (Original) The apparatus of claim 28, wherein  $A_{code}(k) = 1$  at  $k = 0$  and  $A_{code}(k) = 0$  for substantially all  $k \neq 0$ .

33. (Original) The apparatus of claim 28, wherein  $A_{code}(k) = 0$  for  $0 < |k| \leq J$ , wherein J is selected to minimize the correlation of the constrained portion  $Cd_i$  with the one of the codes  $w_0, w_1$  for substantially all  $k \neq 0$ .

34. (Original) The apparatus of claim 33, wherein  $2J$  is a length of the constrained portion  $Cd_i$ .

35. (Previously Presented) The apparatus of claim 28, wherein  $A_{code}(k) = 1$  at  $k = 0$  and  $A_{code}(k) \approx 0$  for substantially all  $k \neq 0$ .

36. (Previously Presented) The apparatus of claim 28, wherein each of the at least two codes  $w_0, w_1$  comprises two symbols.



37. (Previously Presented) The apparatus of claim 28, wherein each of the at least two codes  $w_0, w_1$  comprises no more than two symbols.

38. (Previously Presented) The apparatus of claim 28, wherein the codes  $w_0, w_1$  comprise Walsh codes.

39. (Previously Presented) An apparatus for estimating a communication channel impulse response  $h(t)$ , comprising:

a correlator generating  $co_m(t) = co(t + mNT_c)$  for  $m = 0, 1, \dots, M$  by correlating a received signal  $r(t)$  with a spreading sequence  $S_i$  of length  $N$ , wherein the received signal  $r(t)$  comprises a chip sequence  $c_j$  applied to a communication channel characterizable by the communication channel impulse response  $h(t)$ , and wherein the chip sequence  $c_j$  is generated from a data sequence  $d_i$  spread by the spreading sequence  $S_i$ , and wherein  $T_c$  is the chip period of the chip sequence  $c_j$ ;

an estimator for generating an estimated communication channel impulse response  $\hat{h}_M(t)$  as a combination of  $co_m(t)$  and  $d_m$  for  $m = 0, 1, \dots, M$ , where  $d_m$  is the  $m$ -th symbol and  $M$  is number of symbols used to generate the estimated communication channel impulse response  $\hat{h}_M(t)$ ; and

a filter  $f$  selected at least in part according to the spreading sequence  $S_i$ , the filter for filtering the estimated communication channel impulse response  $\hat{h}_M(t)$  to generate a filtered estimate of the communication channel impulse response  $h(t)$ .

40. (Original) The apparatus of claim 39, wherein the filter  $f$  is further selected at least in part according to an autocorrelation  $A(n)$  of the spreading sequence  $S_i$ .

41. (Previously Presented) The apparatus of claim 40, wherein the filter  $f$  is further selected at least in part according to the duration of the communication channel impulse response  $h(t)$ .

42. (Previously Presented) The apparatus of claim 40, wherein the filter  $f$  is further selected at least in part according to a zero-forcing criteria

$$\sum_{i=-L}^L (A(n-i) \bullet f(i)) = A_f(n), \quad -L \leq n \leq L, \text{ wherein:}$$

$f(i)$  is an impulse response of the filter  $f$  such that  $A_f(n)$  is a convolution of  $A(n)$  and  $f(i)$ ;

$$A_f(n) = 1 \text{ for } n = 0 \text{ and } A_f(n) = 0 \text{ for } 0 < |n| \leq L; \text{ and}$$

$$A(n) = A(-n) = \sum_{i=0}^{N-1-n} S_i \bullet S_{i+n}, \quad 0 \leq n \leq N.$$

43. (Original) The apparatus of claim 42, wherein:  
the parameter  $L$  is chosen such that a time duration of the impulse response of the communication channel  $h(t)$  is less than  $LT_c$ .

44. (Original) The apparatus of claim 42, wherein:  
the parameter  $L$  is chosen such that a time duration of the impulse response of the communication channel  $h(t)$  is approximately equal to  $LT_c$ .

45. (Original) The apparatus of claim 39, wherein  $N$  is less than 20.

46. (Previously Presented) The apparatus of claim 39, wherein  $M = 1$ .

47. (Previously Presented) The apparatus of claim 39, wherein the data sequence  $d_i$  includes a constrained portion  $Cd_i$  associated with at least two codes  $w_0, w_1$ , wherein a correlation  $A_{code}(k)$  of the constrained portion  $Cd_i$  with one of the codes  $w_0, w_1$  is characterized by a maximum value at  $k = 0$  and less than maximum values at  $k \neq 0$ .

48. (Previously Presented) The apparatus of claim 39, wherein the estimator for generating an estimated communication channel impulse response  $\hat{h}_M(t)$  as a combination of  $co_m(t)$  and  $d_m$  for  $m = 0, 1, \dots, M$  comprises means for computing  $\hat{h}_M(t)$  as

$$(1/M) \sum_{m=0}^{M-1} d_m \bullet co(t + mNT_c).$$

49. (Original) The apparatus of claim 48, wherein  $M = 2$ .

50. (Original) The apparatus of claim 47, wherein the data sequence  $d_i$  includes a preamble having a pseudorandom code including the constrained portion of the data sequence  $d_i$ .

51. (Original) The apparatus of claim 47, wherein  $A_{code}(k) = 1$  at  $k = 0$  and  $A_{code}(k) = 0$  for substantially all  $k \neq 0$ .

52. (Original) The apparatus of claim 47, wherein  $A_{code}(k) = 0$  for  $0 < |k| \leq J$ , wherein  $J$  is selected to minimize the correlation of the constrained portion  $Cd_i$  with the one of the codes  $w_0, w_1$  for substantially all  $k \neq 0$ .

53. (Original) The apparatus of claim 52, wherein  $2J$  is a length of the constrained portion  $Cd_i$ .

54. (Previously Presented) The apparatus of claim 47, wherein  $A_{code}(k) = 1$  at  $k = 0$  and  $A_{code}(k) \approx 0$  for substantially all  $k \neq 0$ .

55. (Previously Presented) The apparatus of claim 47, wherein each of the at least two codes  $w_0, w_1$  comprises two symbols.

56. (Previously Presented) The apparatus of claim 47, wherein each of the at least two codes  $w_0, w_1$  comprises no more than two symbols.

57. (Previously Presented) The apparatus of claim 47, wherein the codes  $w_0, w_1$  comprise Walsh codes.

58. (Previously Presented) A method of estimating a communication channel response, comprising:

obtaining a received sequence via a communication channel, the received sequence comprising a chip sequence generated by spreading a data sequence with a spreading sequence;

generating a correlated sequence by correlating the received sequence with the spreading sequence;

generating an estimated communication channel impulse response based on the correlated sequence and a known portion of the data sequence; and

filtering the estimated communication channel impulse response based on a filter to obtain a filtered estimate of the communication channel impulse response, the filter being selected based on the spreading sequence.

59. (Previously Presented) The method of claim 58, wherein the generating the estimated communication channel impulse response comprises

multiplying multiple data symbols in the known portion with the correlated sequence at multiple time offsets, and

generating the estimated communication channel impulse based on a sum of results of the multiplication.

60. (Previously Presented) The method of claim 58, wherein the filter is selected such that convolution of an impulse response of the filter and an autocorrelation of the spreading sequence is non-zero at center of the autocorrelation and is zero for a predetermined range to the left and right of the center of the autocorrelation.

61. (Previously Presented) The method of claim 58, wherein the spreading sequence is an 11-chip Barker sequence.

62. (Previously Presented) The method of claim 58, wherein the known portion of the data sequence is selected such that correlation of the known portion with a code is characterized by a maximum value at one point in the known portion and less than maximum values at all other points in the known portion, and wherein the estimated communication channel impulse response is generated further based on the code.

63. (Previously Presented) An apparatus for estimating a communication channel impulse response, comprising:

means for obtaining a received sequence via a communication channel, the received sequence comprising a chip sequence generated by spreading a data sequence with a spreading sequence;

means for generating a correlated sequence by correlating the received sequence

with the spreading sequence;

means for generating an estimated communication channel impulse response based on the correlated sequence and a known portion of the data sequence; and

means for filtering the estimated communication channel impulse response based on a filter to obtain a filtered estimate of the communication channel impulse response, the filter being selected based on the spreading sequence.

64. (Previously Presented) The apparatus of claim 63, wherein the means for generating the estimated communication channel impulse response comprises

means for multiplying multiple data symbols in the known portion with the correlated sequence at multiple time offsets, and

means for generating the estimated communication channel impulse based on a sum of results of the multiplication.

65. (Previously Presented) The apparatus of claim 63, wherein the filter is selected such that convolution of an impulse response of the filter and an autocorrelation of the spreading sequence is non-zero at center of the autocorrelation and is zero for a predetermined range to the left and right of the center of the autocorrelation.

66. (Previously Presented) The apparatus of claim 63, wherein the spreading sequence is an 11-chip Barker sequence.

67. (Previously Presented) The apparatus of claim 63, wherein the known portion of the data sequence is selected such that correlation of the known portion with a code is characterized by a maximum value at one point in the known portion and less than maximum values at all other points in the known portion, and wherein the estimated communication channel impulse response is generated further based on the code.

68. (Previously Presented) An apparatus for estimating a communication channel impulse response, the apparatus comprising

a processor;

a memory coupled to the processor, wherein the processor is configured to:

a) obtain a received sequence via a communication channel, the received sequence comprising a chip sequence generated by spreading a data sequence with a spreading sequence;

b) generate a correlated sequence by correlating the received sequence with the spreading sequence;

c) generate an estimated communication channel impulse response based on the correlated sequence and a known portion of the data sequence; and

d) filter the estimated communication channel impulse response based on a filter to obtain a filtered estimate of the communication channel impulse response, the filter being selected based on the spreading sequence.

69. (Previously Presented) The apparatus of claim 68, wherein the processor is further configured to



multiply multiple data symbols in the known portion with the correlated sequence at multiple time offsets, and

generate the estimated communication channel impulse based on a sum of results of the multiplication when the processor is configured to generate the estimated communication channel impulse response.

70. (Previously Presented) The apparatus of claim 68, wherein the filter is selected such that convolution of an impulse response of the filter and an autocorrelation of the spreading sequence is non-zero at center of the autocorrelation and is zero for a predetermined range to the left and right of the center of the autocorrelation.

71. (Previously Presented) The apparatus of claim 68, wherein the spreading sequence is an 11-chip Barker sequence.

72. (Previously Presented) The apparatus of claim 68, wherein the known portion of the data sequence is selected such that correlation of the known portion with a code is characterized by a maximum value at one point in the known portion and less than maximum values at all other points in the known portion, and wherein the estimated communication channel impulse response is generated further based on the code.

73. (Currently Amended) A non-transitory computer-readable medium including program code stored thereon, the program code for execution by a processor to

estimate a communication channel impulse response, the non-transitory computer-readable medium comprising:

program codes for obtaining a received sequence via a communication channel, the received sequence comprising a chip sequence generated by spreading a data sequence with a spreading sequence;

program codes for generating a correlated sequence by correlating the received sequence with the spreading sequence;

program codes for generating an estimated communication channel impulse response based on the correlated sequence and a known portion of the data sequence; and

program codes for filtering the estimated communication channel impulse response with a filter to obtain a filtered estimate of the communication channel impulse response, the filter being selected based on the spreading sequence.

74. (Currently Amended) The non-transitory computer-readable medium of claim 73, further comprising:

program codes for multiplying multiple data symbols in the known portion with the correlated sequence at multiple time offsets, and

program codes for generating the estimated communication channel impulse based on a sum of results of the multiplication.

75. (Currently Amended) The non-transitory computer-readable medium of claim 73, wherein the filter is such that convolution of an impulse response of the filter

and an autocorrelation of the spreading sequence is non-zero at center of the autocorrelation and is zero for a predetermined range to the left and right of the center of the autocorrelation.

76. (Currently Amended) The non-transitory computer-readable medium of claim 73, wherein the spreading sequence is an 11-chip Barker sequence.

77. (Currently Amended) The non-transitory computer-readable medium of claim 73, wherein the known portion of the data sequence is such that correlation of the known portion with a code is characterized by a maximum value at one point in the known portion and less than maximum values at all other points in the known portion, and wherein the estimated communication channel impulse response is based on the code.